Infection and Drug Resistance

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Diagnostic Significance of Hematological Parameters and Ratios in the Context of *Mycobacterium* Avium Complex Pulmonary Disease Across Various Age Groups

Xuejuan Long[1,*], Qian Li[2,*], Han Wang[2], Shizheng Wang[2], Zhe Ren[2], Xin Wang[3], Yanjun Gao[2]

[1]Department of Outpatient, Heibei Chest Hospital, Shijiazhuang, 050000, People's Republic of China; [2]Clinical Laboratory, Heibei Chest Hospital, Shijiazhuang, 050000, People's Republic of China; [3]Hebei Province Key Laboratory of Pulmonary Disease, Hebei Chest Hospital, Shijiazhuang, 050000, People's Republic of China

*These authors contributed equally to this work

Correspondence: Yanjun Gao, Clinical Laboratory, Heibei Chest Hospital, Shijiazhuang, 050000, People's Republic of China, Email gaoyanjun7610@163.com

Objective: This investigation intends to clarify the disparities in hematological parameters and ratios among different age groups, providing new insights for the diagnostic of *Mycobacterium* Avium Complex Pulmonary Disease (MAC-PD).

Patients and Methods: A retrospective investigation was undertaken to examine the hematological parameters of elderly (n=88) and non-elderly (n=44) patients diagnosed with MAC-PD at Hebei Chest Hospital between 2020 and 2024. The study involved the calculation of the neutrophil-to-lymphocyte ratio (NLR), lymphocyte-to-monocyte ratio (LMR), platelet-to-lymphocyte ratio (PLR), hemoglobin-to-lymphocyte ratio (HLR),hemoglobin-to-platelet ratio (HPR),systemic inflammatory response index (SIRI) and systemic immune-inflammation index (SII). Statistical analyses were executed utilizing SPSS 27.0 and R (4.2.1) software.

Results: The levels of absolute lymphocyte count (ALC),hemoglobin (Hb) and LMR were lower in Elderly MAC group compared to Non-elderly MAC group. Conversely,the levels of NLR, PLR,HLR,SIRI and SII were higher in Elderly MAC group than in Non-elderly MAC group. There was a certain correlation between the Ct value of MAC nucleic acid and NLR, LMR, SIRI and SII ($P<0.05$) in Elderly MAC group. In Non-elderly MAC group, the Ct value of MAC nucleic acid was correlated with absolute neutrophil count (ANC), LMR, SIRI and SII ($P<0.05$). Receiver operating characteristic curve (ROC) analysis indicated that NLR, LMR, SIRI and SII exhibited high diagnostic value in Elderly MAC group,while LMR, SIRI and SII demonstrated high diagnostic value in Non-elderly MAC group. The combined diagnostic value was even more prominent. Nevertheless,no significant diagnostic indicators were identified between Elderly MAC group and Non-elderly MAC group.

Conclusion: The combination of NLR, LMR, SIRI and SII may serve as diagnostic markers for Elderly MAC-PD and the combination of LMR, SIRI and SII may serve as diagnostic markers for Non-lderly MAC-PD. But there were no significant diagnostic indicators differentiating Elderly MAC group from Non-elderly MAC group.

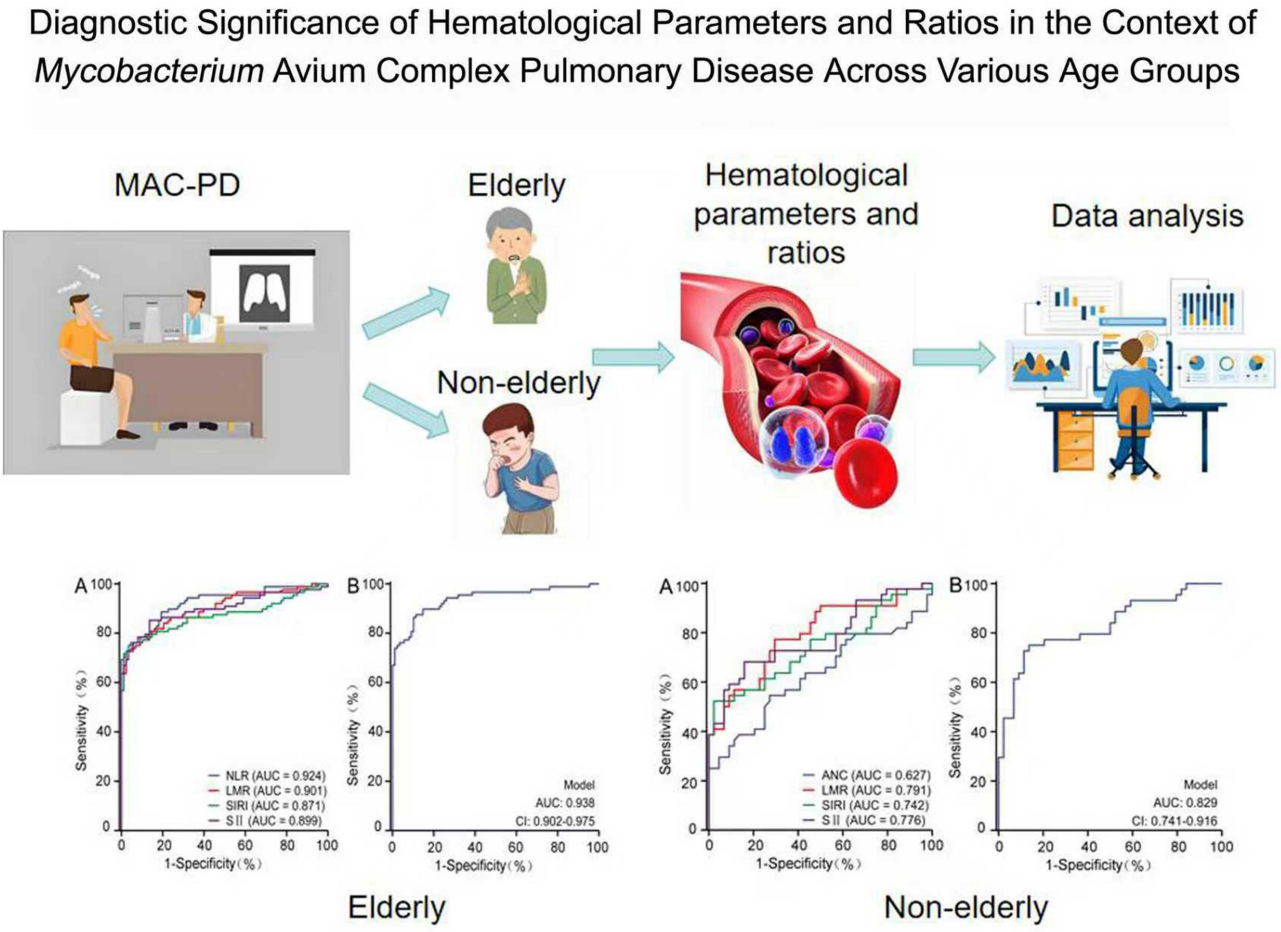
Keywords: MAC-PD, NLR, LMR, PLR, SIRI, SII

Introduction

MAC-PD is a chronic pulmonary infectious disorder induced by the *Mycobacterium* avium complex. In recent years, its incidence has exhibited an upward trend.[1–5]MAC-PD predominantly affects the elderly population, and notable age disparities exert a substantial influence on the clinical phenotype of MAC-PD. Elderly patients primarily exhibit chronic airway lesions, yet their systemic symptoms are not characteristic, and there are concurrent underlying diseases. The CT manifestations encompass bronchiectasis, pectus excavatum, and bronchiectasis with infiltration in the right middle lobe and lingular lobe. Non-elderly patients are inclined to present with acute focal or disseminated lesions, accompanied by

Received: 29 May 2025
Accepted: 27 August 2025
Published: 13 September 2025

Graphical Abstract



more severe systemic symptoms, and are predisposed to focal consolidation and mass shadows. Recognizing these disparities is of critical importance for early diagnosis and preventing misdiagnosis.[6–10] Due to the non-specific clinical manifestations of MAC-PD and the overlapping radioactive manifestations with other pulmonary diseases, the diagnosis of MAC-PD is often delayed.[11–13] Therefore, the exploration of new markers is of great significance for the early diagnosis and treatment of the disease.

In recent years, hematological parameters and ratios (NLR, PLR, PLR, HLR, SIRI, SII, etc) have gradually emerged as research focal points in the diagnosis and prognosis assessment of infectious diseases. This is attributed to their ease of accessibility and sensitivity to inflammation and immune status.[14–17] Nevertheless, numerous factors exert an influence on the alterations in hematological parameters, including acute bacterial infections, burns, traumas, emergency reactions, medications, malignant neoplasms, autoimmune disorders, tuberculosis, syphilis, acquired immunodeficiency syndrome (AIDS) and thrombotic diseases, among others. The pathophysiological mechanisms are also quite intricate. Research has demonstrated that neutrophils can adapt to the tissue environment under pathological circumstances by modulating their metabolic activity through multiple metabolic pathways. Owing to their newly discovered capacity to form inflammasomes and generate neutrophil extracellular traps (NETs), neutrophils have been recognized as pivotal in thromboinflammation.[18,19] Research has indicated that the T-cell function of tuberculosis patients is associated with their antibacterial activity and the recurrence of bacteria.[20,21] Therefore, it is of great significance to establish explicit inclusion and exclusion criteria. As a chronic infectious disease, for MAC-PD, the diagnostic value of hematological

parameters and ratios remains ambiguous. Furthermore, whether age disparities will impact their diagnostic efficacy necessitates further exploration. In light of this,the present study investigated the hematological parameters and ratios of elderly and non-elderly patients with MAC-PD via age stratification,with the objective of screening biomarkers with clinical diagnostic potential and offering a theoretical foundation for optimizing the health management and early diagnosis strategies of MAC-PD.

Materials and Methods

Data Collection and Grouping

A total of 132 patients with a definitive diagnosis of MAC-PD who were admitted to Hebei Chest Hospital from 2020 to 2024 were consecutively recruited (MAC group). Additionally, 132 healthy individuals who underwent physical examinations during the same period were also incorporated (Healthy control group). The MAC group and Healthy control group were precisely matched at a 1:1 ratio in terms of age and gender, comprising 63 females (47.73%) and 69 males (52.27%). Individuals aged 60 years or older were categorized into Elderly group (n=88,65.67%),while those under 60 years were classified into Non-elderly group (n=44,33.33%). Three groups were established:Elderly MAC group (n=88) and Healthy control group (n=88) with ages spanning from 60 to 86 years and a mean age of (69.273 ± 5.618); Non-elderly MAC group (n = 44) and Healthy control group (n=44), with ages ranging from 20 to 59 years and a mean age of (47.773 ± 11.214); as well as Elderly MAC group (n=88) and Non-elderly MAC group (n = 44). Inclusion criteria for MAC group: Patients diagnosed in accordance with the Guidelines for the Diagnosis and Treatment of Nontuberculous *Mycobacterial* Disease (2020 Edition, China) and confirmed to have *Mycobacterium* avium complex infection. Exclusion criteria for MAC group: Incomplete case data; concurrent hematological disorders; concurrent hepatorenal diseases; concurrent severe cardiovascular and cerebrovascular diseases; concurrent acute infections; concurrent AIDS; concurrent diabetes mellitus; concurrent autoimmune disorders; splenectomy; concurrent tuberculosis; concurrent neoplasms; utilization of medications influencing coagulation function and platelet count. Healthy control group was screened to exclude latent infections or inflammatory sources through medical history inquiry and (or) laboratory tests, adhering strictly to well-defined inclusion and exclusion criteria. Inclusion criteria were as follows: absence of recent acute infection; no use of medications influencing platelet count; no history of infectious diseases; no history of hematological diseases; no history of tumors; no history of diabetes; no history of splenectomy; no severe and cerebrovascular diseases; no hepatorenal diseases and no history of autoimmune diseases. The exclusion criteria were formulated in correspondence with the inclusion criteria. Laboratory tests encompassed hematological analysis, liver and kidney function tests, head computed tomography (CT), tumor marker tests, tuberculin test and chest X-ray examinations. Healthy control group was selected based on the principle of random sampling, which involved randomly choosing control subjects from the healthy population that met the matching criteria of the patient group. This study was approved by the hospital's ethics committee and obtained specific informed consent.

Detection Methods and Instruments

In the early morning, 2 mL of EDTA-anticoagulated blood was collected and analyzed using the Mindray XN2800 hematology analyzer. Nontuberculous *mycobacteria* were cultured via the BACTEC MGIT 960 system. The Bruker MALDI Biotyper fully automatic microbial mass spectrometer was employed to identify bacterial strains. The nucleic acid Ct values of nontuberculous *mycobacteria* in sputum were detected with the Bio-Rad CFX96 Deep well fluorescence quantitative PCR instrument. A Ct value of 40 or no detectable value was considered negative, while a Ct value less than 40 was regarded as positive.

Observation Index

White blood cell count (WBC), ANC, ALC, AMC, Hb, PLT and calculated NLR, LMR, PLR, HLR,HPR,SIRI and SII. NLR=Neutrophils/Lymphocytes,LMR= Lymphocytes/Monocytes,PLR=Platelets/Lymphocytes,HLR=,Hemoglobin/Lymphocytes,HPR=Hemoglobin/Platelet,SIRI=Neutrophil×monocyte/Lymphocyte,SII=Platelet×neutrophil/Lymphocyte.

Statistical Analysis

Statistical analysis was performed using SPSS 27.0 and R(4.2.1) software. The measurement data conformed to the normal distribution and homogeneity of variance using the *T* test, expressed as $\bar{x} \pm s$.Welch's test is adopted when the requirement of normality is met but not homogeneity of variance is not. Those that do not meet the requirements of the normal distribution are tested by the non-parametric Mann–Whitney *U*-test, which is expressed by the median inter-quartile range. ROC analysis was performed on the data using the pROC package. Combined diagnostic analysis was conducted when AUC>0.7, and the results were visualized using ggplot2. Binary logistic regression analysis included individual risk factors. The correlation coefficient |R|≥0.3 indicates that there is a correlation between the two variables. |R|<0.3 indicates a weak correlation or no correlation between the two variables; If R is positive, it is positively correlated; if it is negative, it is negatively correlated. The closer the absolute value is to 1, the higher the correlation. The use of the R package is all through the Taoxian Academic Platform (https://www.xiantao.love). $P<0.05$ was considered statistically significant.

Results

Comparison of Various Parameters and Ratios Between Elderly MAC Group and Healthy Control Group

A comparison of hematological parameters and ratios between the two groups showed that there was no statistically significant difference in WBC,$P>0.05$. There were statistically significant differences in ANC, ALC, AMC, Hb, PLT, NLR, LMR, PLR, HLR, HPR, SIRI and SII,$P<0.05$. Among them, the levels of ANC, AMC, PLT, NLR, PLR, HLR, SIRI and SII were significantly increased. The levels of ALC, Hb, LMR and HPR were significantly decreased, as shown in Table 1 and Figure 1.

Comparison of Various Parameters and Ratios Between Non-Elderly MAC Group and Healthy Control Group

A comparison of hematological parameters and ratios between the two groups showed that there was no statistically significant difference in WBC, AMC and PLT, $P>0.05$. The differences in ANC, ALC, Hb, NLR, LMR, PLR, HLR, HPR, SIRI and SII were statistically significant,$P<0.05$. Among them, the levels of ANC, NLR, PLR, HLR, SIRI and SII increased significantly, while the levels of ALC,Hb,LMR and HPR decreased,as shown in Table 2 and Figure 2.

Table 1 Comparison of Various Parameters and Ratios Between Elderly MAC Group and Healthy Control Group

Parameters	Healthy Control (n=88)	Elderly MAC(n=88)	*Z* or *t*	*P*-value
WBC	5.970(5.163,7.008)	6.495(5.040,8.275)	$Z=-1.740$	$P=0.082$
ANC	3.345(2.770,4.160)	4.800(3.450,6.370)	$Z=-5.632$	$P<0.001$
ALC	2.055(1.733,2.403)	1.060(0.805,1.410)	$Z=-9.170$	$P<0.001$
AMC	0.355(0.298,0.440)	0.430(0.310,0.535)	$Z=-2.905$	$P<0.01$
Hb	141.760±12.371	116.940±16.148	$t=12.650$	$P<0.001$
PLT	218.500 (195.500,255.750)	282.500 (210.000,335.500)	$Z=-4.468$	$P<0.001$
NLR	1.596 (1.315,2.062)	4.121 (2.765,7.046)	$Z=-9.723$	$P<0.001$
LMR	6.092 (4.516,6.890)	2.659 (1.829,3.735)	$Z=-9.193$	$P<0.001$
PLR	105.730 (86.205,138.180)	234.92 (178.790,376.930)	$Z=-9.640$	$P<0.001$
HLR	67.953 (61.049,80.805)	110.05 (78.432,143.97)	$Z=-6.921$	$P<0.001$
HPR	0.650 (0.535,0.773)	0.419 (0.323,0.609)	$Z=-6.836$	$P<0.001$
SIRI	0.586 (0.467,0.793)	1.787 (1.04,3.205)	$Z=-8.507$	$P<0.001$
SII	372.15 (274.32,453.2)	1193.2 (693.94,2029.2)	$Z=-9.140$	$P<0.001$

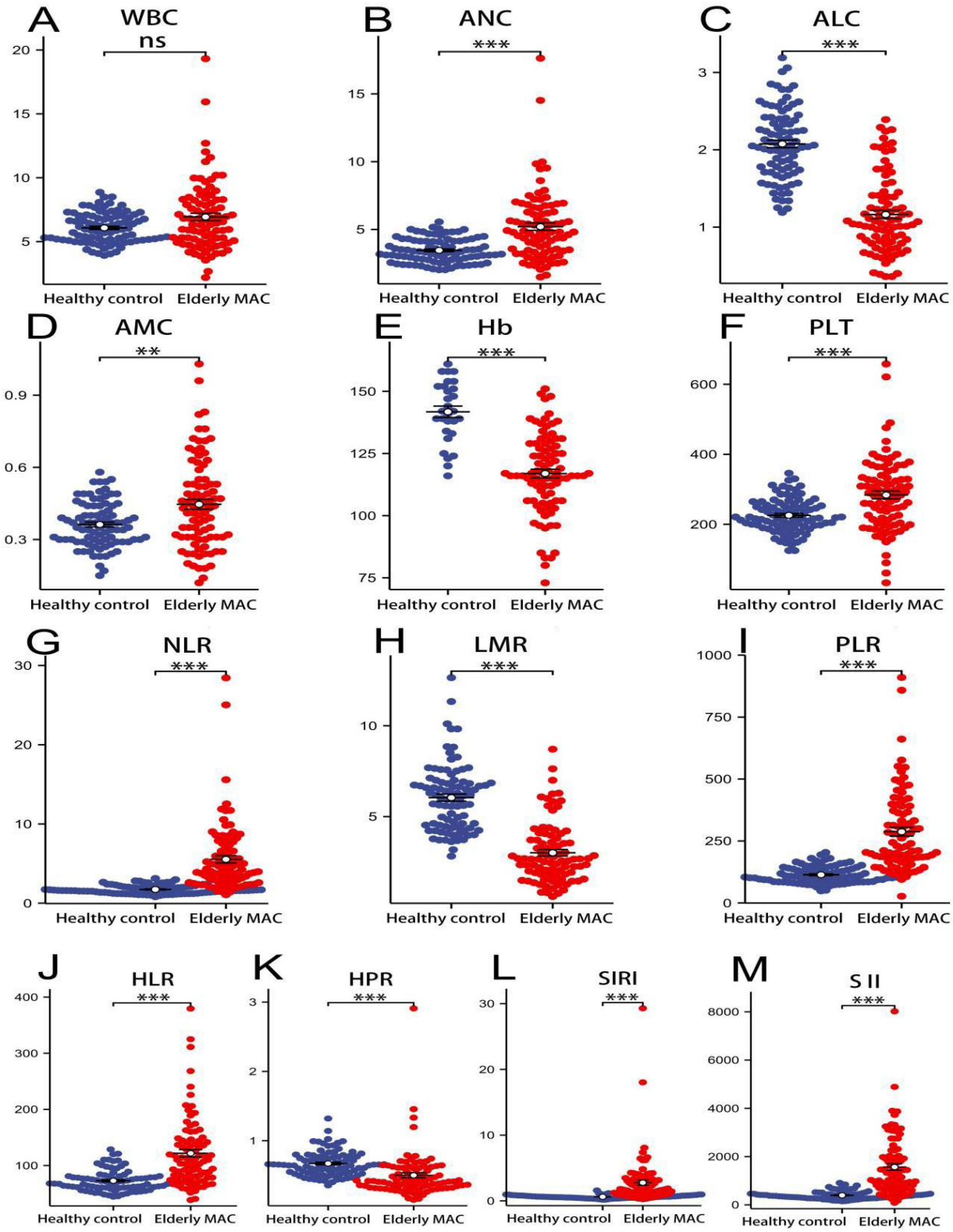


Figure 1 Comparison of cellular graph across multiple parameters and ratios between Elderly MAC group and Healthy control group.
Notes:(**A**) WBC; (**B**) ANC; (**C**) ALC; (**D**) AMC; (**E**) Hb; (**F**) PLT; (**G**) NLR; (**H**) LMR; (**I**) PLR; (**J**) HLR; (**K**) HPR; (**L**) SIRI; (**M**) SII; ns means no significance; ***P*<0.01; ****P*<0.001,Red,Elderly MAC group; blue, Healthy control group.

https://doi.org/10.2147/IDR.S543622

Table 2 Comparison of Various Parameters and Ratios Between Non-Elderly MAC Group and Healthy Control Group

Parameters	Healthy Control (n=44)	Non-Elderly MAC(n=44)	*Z* or *t*	*P*-value
WBC	6.015 (5.26,6.858)	6.045 (4.98,7.433)	*Z*=−0.029	*P*=0.977
ANC	3.4 (2.75,4.135)	4.105 (3.133,5.33)	*Z*=−2.053	*P*=0.040
ALC	2.133±0.432	1.431±0.483	*t*=7.196	*P*<0.001
AMC	0.32(0.26,0.393)	0.34(0.26,0.488)	*Z*=−0.964	*P*=0.335
Hb	140.05±12.186	123.82±15.498	*t*=5.460	*P*<0.001
PLT	244(226.75,267.5)	261.5(216.5,320)	*Z*=−1.310	*P*=0.190
NLR	1.705(1.228,1.933)	2.835(1.933,4.001)	*Z*=−4.740	*P*<0.001
LMR	6.71±1.937	4.345±2.219	*t*=5.326	*P*<0.001
PLR	118.29(93.255,143.86)	178.06(139.08,237.36)	*Z*=−5.867	*P*<0.001
HLR	67.102(57.899,77.054)	88.459(75.579,101.55)	*Z*=−4.815	*P*<0.001
HPR	0.555(0.514,0.635)	0.478(0.380,0.586)	*Z*=−3.096	*P*=0.002
SIRI	0.477(0.365,0.811)	1.107(0.549,1.856)	*Z*=−3.914	*P*<0.001
SII	418.03(296.25,477.9)	741.42(398.2,1320.2)	*Z*=−4.465	*P*<0.001

Comparison of Various Parameters and Ratios Between Elderly MAC Group and Non-Elderly MAC Group

A comparison of hematological parameters and ratios between the two groups showed that there was no statistically significant difference in WBC, ANC, AMC, PLT and HPR, $P>0.05$. The differences in ALC, Hb, NLR, LMR, PLR, HLR, SIRI and SII were statistically significant. Among them, the levels of NLR, PLR,HLR,SIRI and SII were significantly increased, while the levels of ALC, Hb and LMR were significantly decreased, $P<0.05$, as shown in Table 3 and Figure 3.

Correlation Analysis

Compared with Healthy control group, the statistically significant indicators in Elderly MAC group were ANC, ALC, AMC, Hb, PLT, NLR, LMR, PLR, HLR, HPR, SIRI and SII.Spearman correlation analysis was employed to conduct a statistical examination of the correlation between these differential indicators and the Ct value of MAC nucleic acid. The results showed that MAC Ct value had certain correlations with NLR, LMR, SIRI and SII,$P<0.05$, and the difference was statistically significant. The correlation coefficients and P values were (−0.328,0.002), (0.339, 0.001), (−0.336, 0.001) and (−0.346, 0.001), respectively. Among them, LMR was positively correlated, while NLR, SIRI, and SII were negatively correlated, as shown in Table 4 and Figure 4. Compared with Healthy control group, the statistically significant indicators in Non-elderly MAC group were ANC, ALC, Hb, NLR, LMR, PLR, HLR, HPR, SIRI and SII. Spearman correlation analysis was used to statistically analyze the correlation between these differential indicators and the Ct value of MAC nucleic acid. The results showed that the Ct value of MAC nucleic acid had certain correlations with ANC, LMR, SIRI and SII,$P<0.05$, and the difference was statistically significant. The correlation coefficients and P values were (−0.328,0.030), (0.359, 0.017), (−0.364, 0.015) and (−0.326, 0.031), respectively. Among them, LMR is positively correlated, while ANC, SIRI and SII are negatively correlated,as shown in Table 5 and Figure 5.

ROC Curve Analysis for Elderly Group and Non-Elderly Group

This research carried out ROC curve analysis on the indicators with strong correlations. The results of the ROC curve analysis for Elderly MAC group and Healthy control group indicated that the NLR, LMR,SIR and SII exhibited relatively high diagnostic accuracy, with area under the curve (AUC) values of 0.924, 0.901, 0.871 and 0.899, respectively, as shown in Figure 6A. As shown in Figure 6B, the combined diagnosis exhibited a higher level of accuracy, with an AUC value of 0.938. The ROC curve analysis results of the Non-elderly MAC group and Healthy control group showed that

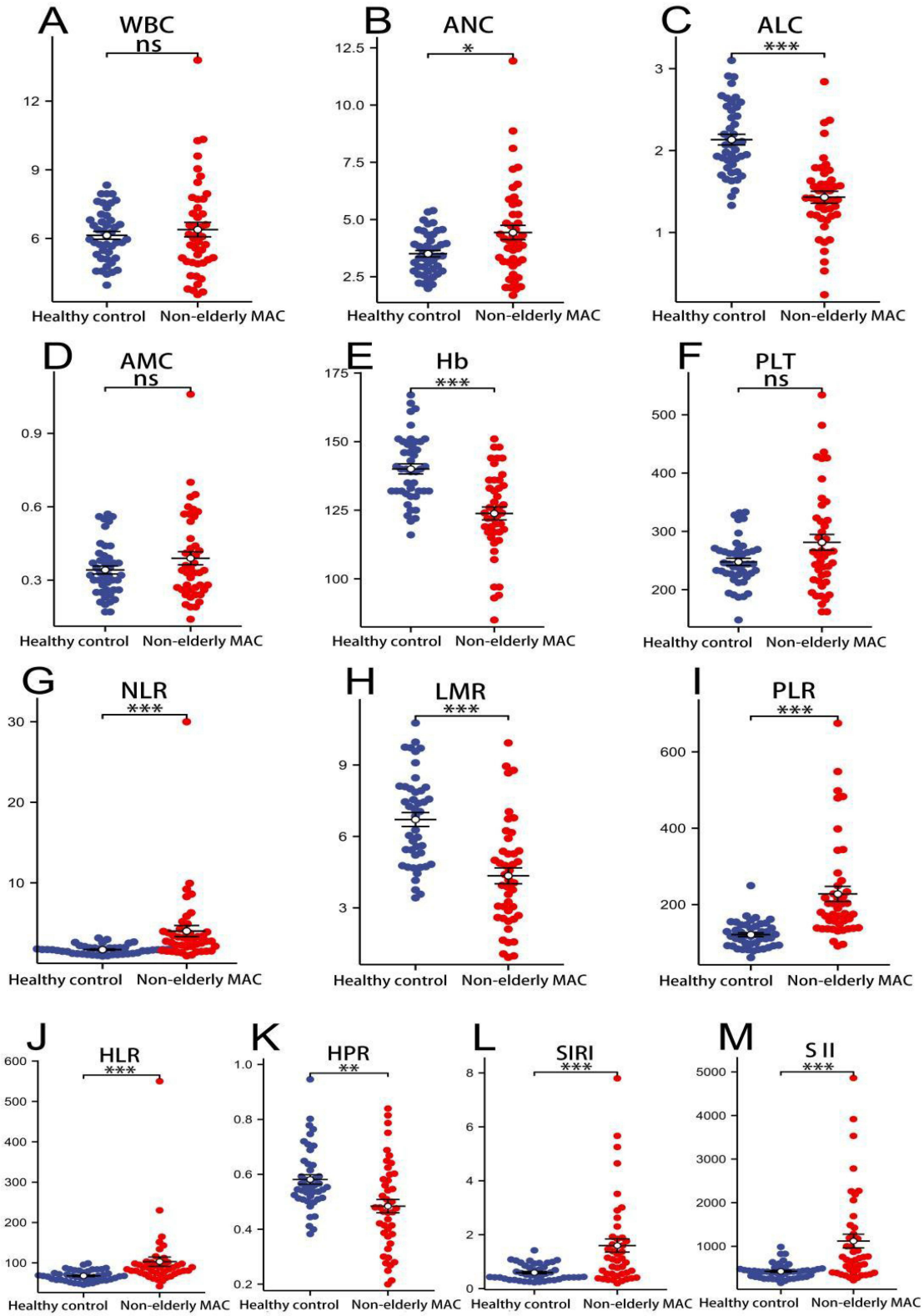


Figure 2 Comparison of cellular graph across multiple parameters and ratios between Non-elderly MAC group and Healthy control group.
Notes: (**A**) WBC; (**B**) ANC; (**C**) ALC; (**D**) AMC; (**E**) Hb; (**F**) PLT; (**G**) NLR; (**H**) LMR; (**I**) PLR; (**J**) HLR; (**K**) HPR; (**L**) SIRI; (**M**) SII;ns means no significance; **P*<0.05; ***P*<0.01; ****P*<0.001, Red, Elderly MAC group;blue,Non-elderly MAC group.

https://doi.org/10.2147/IDR.S543622

Table 3 Comparison of Various Parameters and Ratios Between Elderly MAC Group and Non-Elderly MAC Group

Parameters	Non-Elderly MAC(n=44)	Elderly MAC (n=88)	*Z* or *t*	*P*-value
WBC	6.045 (4.98,7.432)	6.495 (5.04,8.275)	*Z*=−1.052	*P*=0.293
ANC	4.105 (3.132,5.33)	4.8 (3.45,6.37)	*Z*=−1.909	*P*=0.056
ALC	1.41 (1.208,1.633)	1.06 (0.805,1.41)	*Z*=−3.360	*P*<0.001
AMC	0.34(0.26,0.488)	0.43(0.31,0.535)	*Z*=−1.849	*P*=0.064
Hb	123.82±15.498	116.94±16.148	*t*=2.337	*P*=0.021
PLT	261.5(216.5,320)	282.5(210,335.5)	*Z*=−0.422	*P*=0.673
NLR	2.835(1.933,4.001)	4.121(2.765,7.046)	*Z*=−3.215	*P*<0.001
LMR	4.115(2.658,5.380)	2.659(1.829,3.735)	*Z*=−3.572	*P*<0.001
PLR	178.06(139.08,237.36)	234.92(178.79,376.93)	*Z*=−2.389	*P*=0.017
HLR	88.459(75.579,101.55)	110.05(78.432,143.97)	*Z*=−2.472	*P*=0.013
HPR	0.478(0.380,0.586)	0.419(0.323,0.609)	*Z*=−0.934	*P*=0.350
SIRI	1.107(0.549,1.856)	1.787(1.04,3.205)	*Z*=−3.041	*P*=0.002
SII	741.42(398.2,1320.2)	1193.2(693.94,2029.2)	*Z*=−2.650	*P*=0.008

LMR, SIRI and SII exhibited relatively high diagnostic accuracies, with AUC values of 0.791, 0.742, and 0.776, respectively, as shown in Figure 7A. The combined diagnosis had higher accuracy, with an AUC value of 0.829, as shown in Figure 7B. The analysis results of ROC curve for Elderly MAC group and Non-elderly MAC group indicated that all hematological parameters and ratios exhibited relatively low diagnostic accuracy. This implies that there were no significant diagnostic indicators differentiating Elderly MAC group from Non-elderly MAC group, as shown in Figure 8.

Binary Logistic Regression Analysis Between Elderly Group and Non-Elderly Group

This research conducted binary logistic regression analysis on the indicators with high diagnostic value for both Elderly group and Non-elderly group. The binary logistic regression analysis results showed that NLR was a risk factor for the occurrence and development of MAC-PD in the elderly, as shown in Table 6; SII was a risk factor for the occurrence and development of MAC-PD in the non-elderly, as shown in Table 7.

Discussion

Nontuberculous *mycobacteria* refer to a group of *mycobacteria* distinct from the *Mycobacterium* tuberculosis complex and *Mycobacterium* leprae. The pulmonary disorder induced by these *mycobacteria* is termed nontuberculous *mycobacterial* pulmonary disease. Among these, MAC-PD represents the most prevalent type. The diagnosis generally poses challenges and necessitates differentiation from pulmonary tuberculosis, fungal infections, and bacterial infections.[22–25] The physiological characteristics of elderly patients with MAC-PD are different from those of young people, such as low immunity, atypical symptoms, limited invasive examination methods, multiple diseases coexistence and treatment contradictions and delayed medical treatment, all of which cause great difficulties in the diagnosis of the disease. Therefore, a simple, convenient, low-cost, and short-duration diagnostic method is particularly necessary. In recent years, peripheral hematological parameters and ratios have demonstrated a certain degree of diagnostic utility in the diagnosis, differential diagnosis, survival analysis and assessment of complications associated with tuberculosis. This is attributed to their advantages of convenience, cost-effectiveness and strong correlation with the body's immune-inflammatory response.[26–29]Nevertheless, limited research has been conducted on the diagnostic significance of inflammatory markers for nontuberculous *mycobacterial* pulmonary disease.

This research comprehensively analyzed multiple hematological parameters and ratios of patients with MAC-PD to screen out diagnostic markers. The research was stratified into Elderly MAC group and Healthy control group, Non-elderly MAC group and Healthy control group, and Elderly MAC group and Non-elderly MAC group. It revealed the

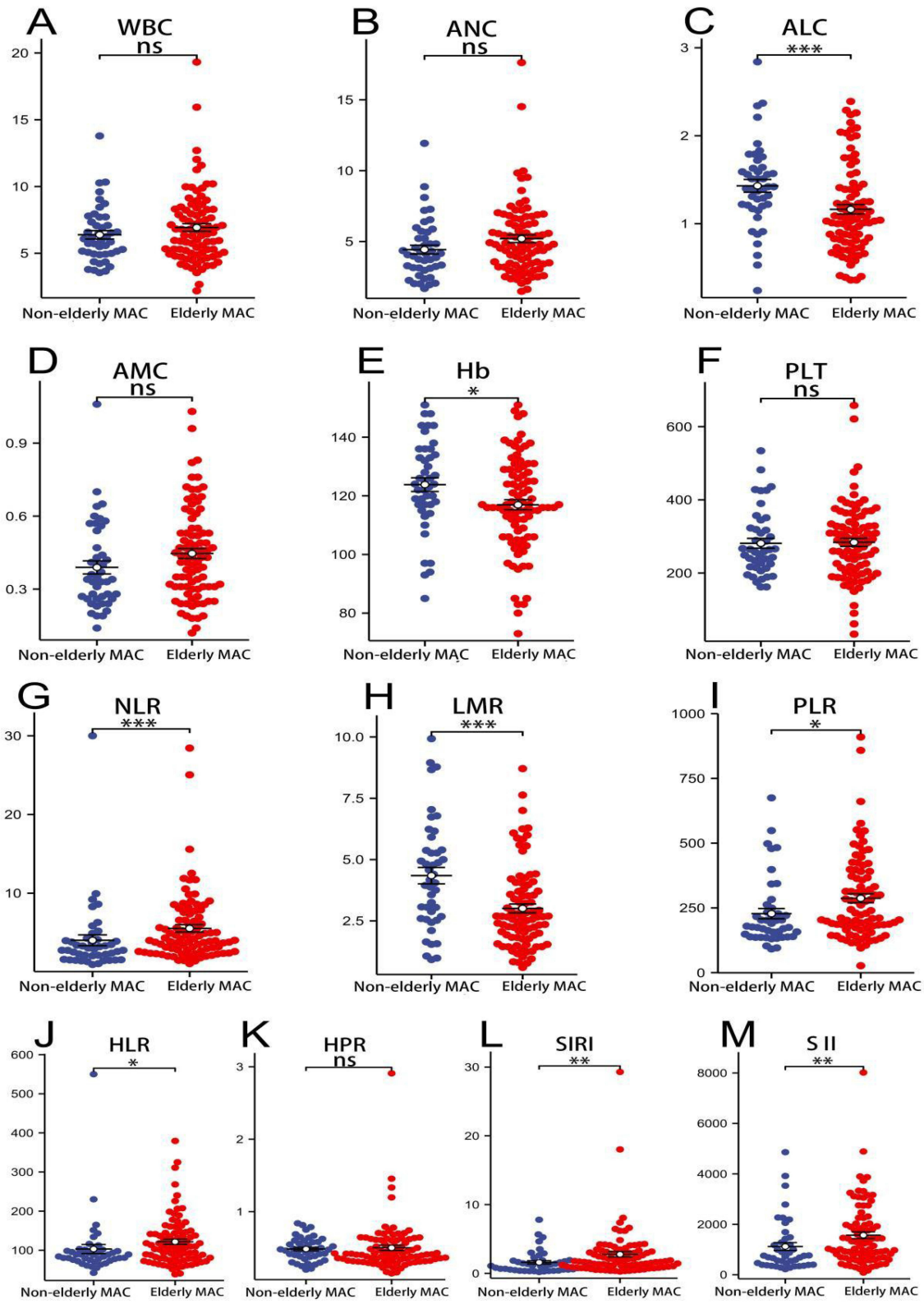


Figure 3 Comparison of cellular graph across multiple parameters and ratios between Elderly MAC group and Non-elderly MAC group.
Notes:(**A**) WBC; (**B**) ANC; (**C**) ALC; (**D**) AMC; (**E**) Hb; (**F**) PLT; (**G**) NLR; (**H**) LMR; (**I**) PLR; (**J**) HLR; (**K**) HPR; (**L**) SIRI; (**M**) SII;ns means no significance; **P*<0.05; ***P*<0.01; ****P*<0.001,Red,Elderly MAC group;blue,Non-elderly MAC group.

https://doi.org/10.2147/IDR.S543622

Table 4 Correlation Between MAC Nucleic Acid Detection and Blood Cell Parameters and Ratios in Elderly Group

Master Variable	Subvariable	df	stat	R	*P* value
MAC Ct value	ANC	86	138,613.956	−0.221	*P*=0.039
MAC Ct value	ALC	86	90,388.636	0.204	*P*=0.057
MAC Ct value	AMC	86	141,955.918	−0.250	*P*=0.019
MAC Ct value	Hb	86	91,946.742	0.190	*P*=0.076
MAC Ct value	PLT	86	134,697.274	−0.186	*P*=0.083
MAC Ct value	NLR	86	150,861.777	−0.328	*P*=0.002
MAC Ct value	LMR	86	75,013.594	0.339	*P*=0.001
MAC Ct value	PLR	86	144,093.510	−0.269	*P*=0.011
MAC Ct value	HLR	86	131,118.112	−0.155	*P*=0.150
MAC Ct value	HPR	86	86,784.111	0.236	*P*=0.027
MAC Ct value	SIRI	86	151,736.580	−0.336	*P*=0.001
MAC Ct value	SII	86	152,821.173	−0.346	*P*=0.001

Abbreviations: df, degree of freedom; stat, statistical magnitude; R, Correlation coefficient.

differences in diagnostic markers among different age groups. The results showed that compared with Healthy control group, the levels of ANC, AMC, PLT, NLR, PLR, HLR, SIRI and SII were significantly increased in Elderly MAC patients, while the levels of ALC, Hb, LMR and HPR were significantly decreased; In Non-elderly MAC group,the levels

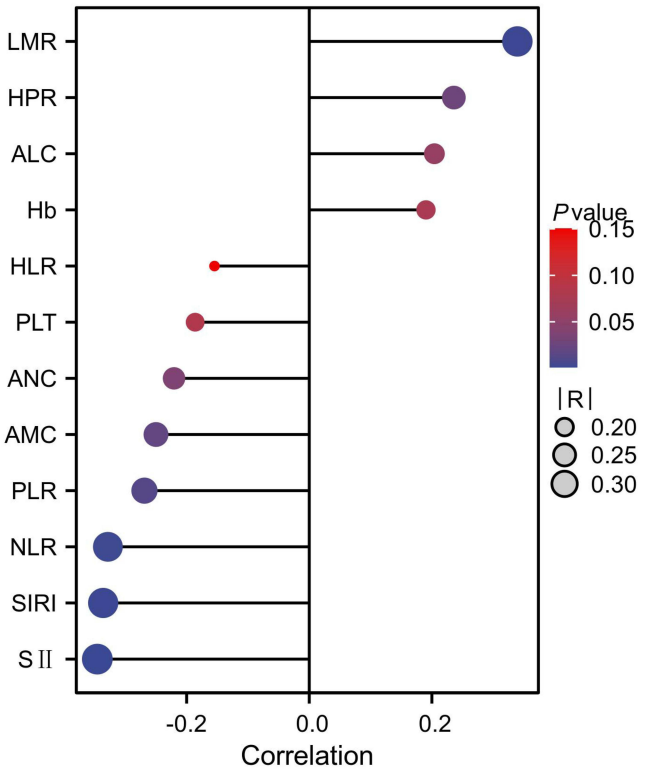


Figure 4 Correlation between MAC nucleic acid and hematological parameters and ratios in Elderly group.
Notes: |R|, Absolute value of the correlation coefficient; Horizontal coordinate, Represents the principal variable; The vertical coordinate, represents the correlation coefficient between the primary variable and the secondary variable; Point, It represents the correlation coefficient of the mapping between the primary variable and the secondary variable. The larger the point, the greater the absolute value of the correlation coefficient between the primary variable and the secondary variable. Horizontal line, the longer the horizontal line, the greater the correlation coefficient.Color, Map the *P* value. The more the color leans towards red, the larger the *P* value; the more the color leans towards blue, the smaller the *P* value.

Table 5 Correlation Between MAC Nucleic Acid Detection and Blood Cell Parameters and Ratios in Non-Elderly Group

Master Variable	Subvariable	df	stat	R	*P* value
MAC Ct value	ANC	42	18,842.231	−0.328	*P*=0.030
MAC Ct value	ALC	42	13,121.894	0.075	*P*=0.627
MAC Ct value	Hb	42	14,988.370	−0.056	*P*=0.717
MAC Ct value	NLR	42	17,828.291	−0.256	*P*=0.093
MAC Ct value	LMR	42	9096.186	0.359	*P*=0.017
MAC Ct value	PLR	42	18,394.843	−0.296	*P*=0.051
MAC Ct value	HLR	42	14,832.779	−0.045	*P*=0.770
MAC Ct value	HPR	42	11,102.809	0.218	*P*=0.156
MAC Ct value	SIRI	42	19,355.920	−0.364	*P*=0.015
MAC Ct value	SII	42	18,821.302	−0.326	*P*=0.031

Abbreviations: df, degree of freedom; stat, statistical magnitude; R, Correlation coefficient.

of ANC, NLR, PLR, HLR, SIRI and SII were significantly increased, while the levels of ALC, Hb, LMR and HPR were decreased. The results of the two groups showed that regardless of whether the patients were elderly or not, the levels of ANC, NLR, PLR, HLR, SIRI and SII were increased, while the levels of ALC, Hb, LMR and HPR were decreased. The difference was that AMC and PLT were increased in elderly patients,while there was no significant change in the non-

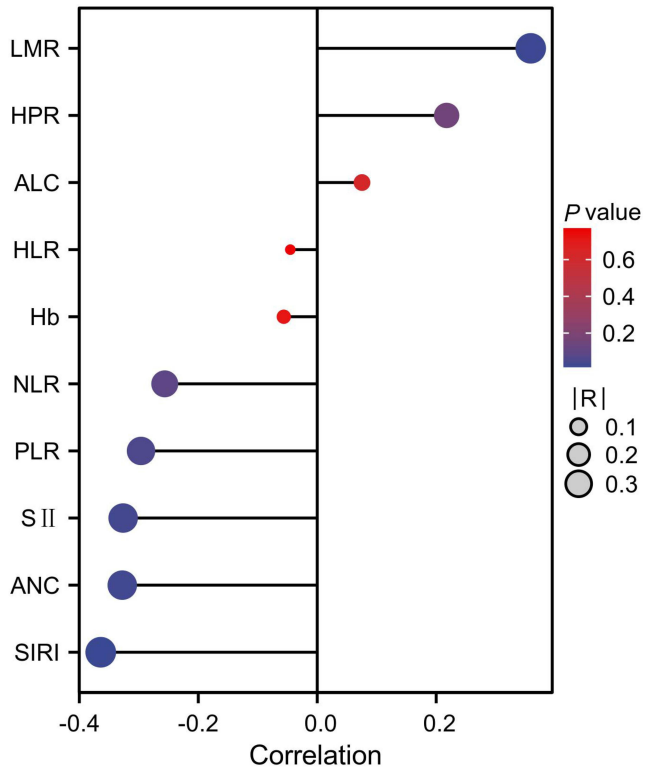


Figure 5 Correlation between MAC-PD nucleic acid and hematological parameters and ratios in Non-elderly group.

Notes: |R|, Absolute value of the correlation coefficient; Horizontal coordinate,Represents the principal variable; The vertical coordinate, represents the correlation coefficient between the primary variable and the secondary variable; Point, It represents the correlation coefficient of the mapping between the primary variable and the secondary variable.The larger the point, the greater the absolute value of the correlation coefficient between the primary variable and the secondary variable. Horizontal line, the longer the horizontal line, the greater the correlation coefficient. Color, Map the *P* value. The more the color leans towards red, the larger the *P* value; the more the color leans towards blue, the smaller the *P* value.

https://doi.org/10.2147/IDR.S543622

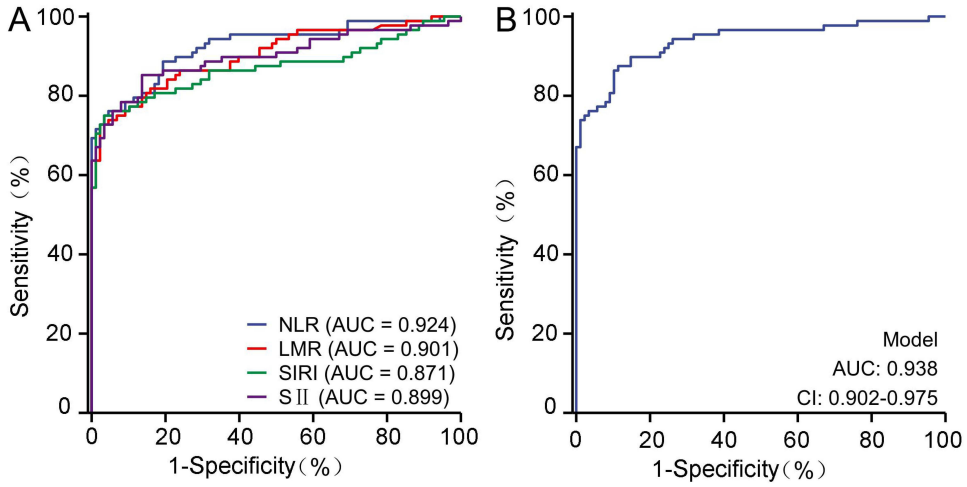


Figure 6 ROC curve analysis was conducted for Elderly MAC group and Healthy control group.
Notes: (**A**) the diagnostic value of NLR, LMR, SIRI and SII. (**B**) the combined diagnostic value of NLR, LMR, SIRI and SII.

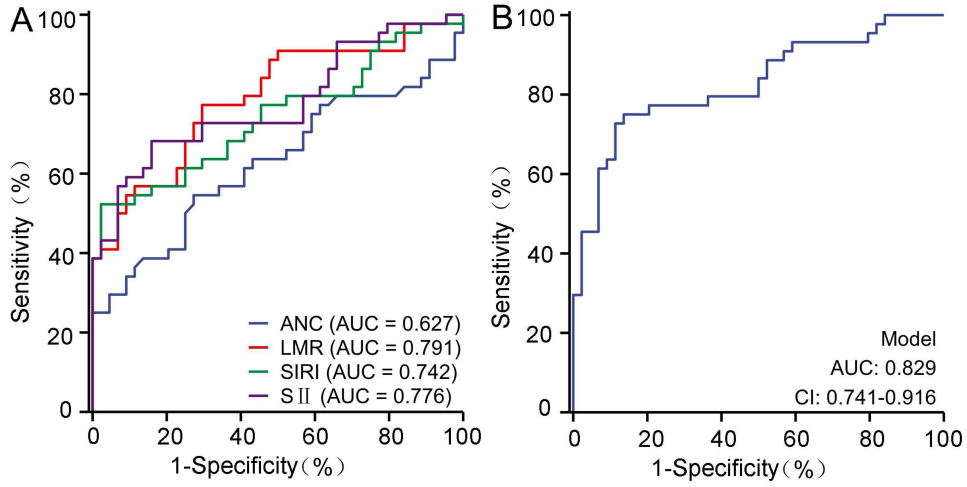


Figure 7 ROC curve analysis was conducted for Non-elderly MAC group and Healthy control group.
Notes: (**A**)the diagnostic value of NLR, LMR, SIRI and SII. (**B**) the combined diagnostic value of NLR, LMR, SIRI and SII.

elderly patients. The levels of ALC,Hb and LMR were lower in elderly patients than in non-elderly patients, and the levels of NLR, PLR, HLR, SIRI and SII were higher in elderly patients than in non-elderly patients.

Mycobacterial nucleic acid testing plays an important role in the diagnosis of tuberculosis and nontuberculous diseases,[30,31] and significantly saves time compared to traditional *mycobacterial* culture. This research employed the Ct value of MAC nucleic acid as the primary variable and hematological parameters and ratios as secondary variables, carried out a Spearman correlation analysis. The findings indicated that the MAC Ct value of elderly patients was correlated with NLR, LMR, SIRI and SII. Specifically, it exhibited a positive correlation with LMR, suggesting that a lower LMR value corresponded to a smaller Ct value. Moreover, a larger quantity of MAC-PD infectious bacteria facilitated diagnosis. Conversely, it was negatively correlated with NLR, SIRI, and SII, implying that a higher value of these indices was associated with a smaller Ct value, and a larger amount of MAC-PD infectious bacteria made diagnosis more straightforward. In the non-elderly patients, the MAC Ct value exhibited correlations with ANC, LMR,SIRI and

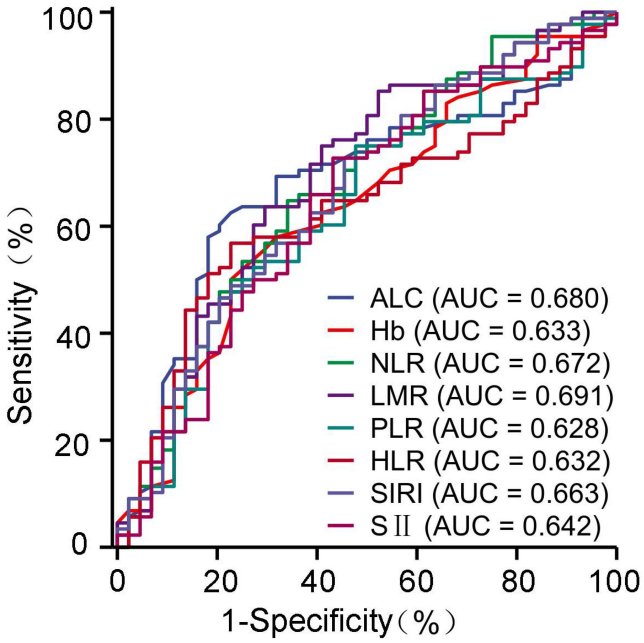


Figure 8 ROC curve analysis was conducted for Elderly MAC group and Non-elderly MAC group.

SII. Specifically, it was positively correlated with LMR, suggesting that a lower LMR value corresponded to a smaller Ct value, and a larger quantity of MAC-PD infectious bacteria facilitated diagnosis. Conversely, it was negatively correlated with ANC, SIRI, and SII, indicating that higher values of these indices were associated with a smaller Ct value and a larger amount of MAC-PD infectious bacteria made diagnosis more straightforward. Regardless of whether it is the elderly group or the non-elderly group, the LMR exhibits a positive correlation, whereas the SIRI and SII demonstrate a negative correlation. The disparity lies in that NLR exhibited a negative correlation with elderly patients with infections, while ANC showed a negative correlation with non-elderly patients with infections. ROC curve analysis indicated that in Elderly MAC group, the diagnostic efficacy of the NLR, LMR,SIRI and SII was substantial. In Non-

Table 6 Binary Logistic Regression Analysis in Elderly Group

Parameters	β	SE	Wald χ^2	*P* value	OR	95% CI
NLR	1.562	0.542	8.300	0.004	4.768	(1.648,13.798)
LMR	−0.507	0.219	5.344	0.021	0.602	(0.392,0.926)
SIRI	−1.159	0.805	2.073	0.150	0.314	(0.065,1.520)
SII	0.002	0.001	2.794	0.095	1.002	(1.000,1.005)

Table 7 Binary Logistic Regression in Non-Elderly Group

Parameters	β	SE	Wald χ^2	*P*-value	OR	95% CI
LMR	−0.449	0.212	4.499	0.034	0.638	(0.421,0.966)
SIRI	−1.490	1.155	1.663	0.197	0.225	(0.023,2.169)
SII	0.004	0.002	5.653	0.017	1.004	(1.001,1.008)

https://doi.org/10.2147/IDR.S543622

elderly MAC group, LMR, SIRI and SII exhibited high diagnostic efficacy. The results of Logistic regression analysis indicated that the NLR served as a risk factor for the onset and progression of MAC-PD in elderly patients, whereas SII was identified as a risk factor for the onset and progression of MAC-PD in non-elderly patients.

Conclusion

This research puts forward an age-specific application strategy regarding hematological parameters and ratios in the diagnosis of MAC-PD. An effort was made to construct novel combinations, including NLR, LMR, SIRI and SII, so as to assess their diagnostic value in elderly patients with MAC-PD, as well as the diagnostic value of LMR, SIRI, and SII in non-elderly patients with MAC-PD. It offers specific insights for the screening of early diagnostic markers in MAC-PD. This research exhibits certain limitations. Concerning the applicability of these parameters in *Mycobacterium* avium infections, their clinical practical significance, diagnostic processes, the mode of their application, whether they serve as confirmation methods or auxiliary references, and whether they impact hospital treatment or prognosis, these issues necessitate further investigation. It is imperative to distinguish them from tuberculosis, bacterial pneumonia, and other forms of nontuberculous *mycobacterial* infections (eg, *Mycobacterium* abscesses, *Mycobacterium* kansasii, etc)., without being confined to the aforementioned diseases. This also represents the work that will be implemented in the subsequent step. Offering a cost-effective and readily scalable auxiliary diagnostic tool for clinical application. In the subsequent research, it is imperative to further enlarge the sample size and integrate dynamic monitoring data to validate the long-term prognostic value of these indicators and their underlying biological mechanisms.

Abbreviations

MAC-PD, *Mycobacterium* avium complex pulmonary disease; WBC, White hematological count; ANC, absolute neutrophil count; ALC, absolute lymphocyte count; AMC, absolute monocyte count; Hb, hemoglobin; PLT, platelet count; NLR, neutrophil to lymphocyte ratio; LMR, lymphocyte to monocyte ratio; PLR, platelet to lymphocyte ratio; HLR, hemoglobin to lymphocyte ratio; HPR, hemoglobin to platelet ratio; SIRI, systemic inflammatory response index; SII, systemic immune inflammatory index; ROC, receiver operating characteristic curve; df, degree of freedom; stat, statistical magnitude; R, Correlation coefficient; Ct value, cycle threshold.

Ethics Approval and Informed Consent

This research employed a retrospective analysis and a non-interventional study design, waiving informed consent. All patient data were anonymously collected, and the confidentiality of their information was ensured. The entire research was carried out in accordance with the principles stipulated in the Declaration of Helsinki. This research was approved by the Medical Ethics Committee of Hebei Provincial Chest Hospital (2022044).

Acknowledgments

We express our sincere gratitude to Meina Li and Mingyue Sun for their contributions to data collection, and to Yongshuo Liu for his support in experimental design.

Funding

This study was funded by Medical Science Research Project of Hebei (20231230).

Disclosure

The authors declare that they have no competing interests in this work.

References

1. Zomer D, van Ingen J, Hofland R. Epidemiology and management of nontuberculous mycobacterial disease in people with cystic fibrosis, the Netherlands. *J Cyst Fibros*. 2023;22(2):327–333. doi:10.1016/j.jcf.2022.10.009
2. Ojo OT, Odeyemi AO. Non-mycobacteria tuberculosis in Africa: a literature review. *Ethiop J Health Sci*. 2023;33(5):913–918. doi:10.4314/ejhs.v33i5.21
3. Steindor M, Hafkemeyer S, Ruckes C, et al. Epidemiological trends in nontuberculous mycobacterial infection among people with cystic fibrosis in Germany. *Int J Infect Dis*. 2023;129:32–39. doi:10.1016/j.ijid.2023.01.032
4. Wang D, Liu H, Zheng Y, et al. Epidemiology of nontuberculous mycobacteria in tuberculosis suspects, southwest of China, 2017-2022. *Front Cell Infect Microbiol*. 2023;13:1282902. doi:10.3389/fcimb.2023.1282902
5. Lee EH, Chin B, Kim YK, et al. Clinical characteristics of nontuberculous mycobacterial disease in people living with hiv/aids in South Korea: a multi-center, retrospective study. *PLoS One*. 2022: 17:e276484. doi:10.1371/journal.pone.0276484
6. Daley CL, Winthrop KL. Mycobacterium avium complex: addressing gaps in diagnosis and management. *J Infect Dis*. 2020;222(Supplement_4): S199–S211. doi:10.1093/infdis/jiaa354
7. Metersky ML, Fraulino D, Lea Monday L, et al. Current challenges in pulmonary nontuberculous mycobacterial infection: a case series with literature review. *Postgrad Med*. 2024;136(7):770–781. doi:10.1080/00325481.2024.2401766
8. Dahl VN, Pedersen AA, van Ingen J, et al. Relationship between age, sex, geography and incidence of nontuberculous mycobacteria in Denmark from 1991 to 2022. *ERJ Open Res*. 2025;11(2):00437–2024. doi:10.1183/23120541.00437-2024
9. Dahl VN, Fløe A, Rudolf F, et al. Clinical characteristics and diagnostic practices in nontuberculous mycobacterial pulmonary disease: insights from Denmark. *Respir Med*. 2025;241:108055. doi:10.1016/j.rmed.2025.108055
10. Feng YP, Guo J, Luo SR, et al. Phenotyping nontuberculous mycobacterial lung disease: comparative analysis of clinical and imaging features in a TB-endemic setting. *Infect Drug Resist*. 2025;18:3527–3534. doi:10.2147/IDR.S529466
11. Hayashi M, Takishima H, Kishino S, et al. Time to diagnosis of nontuberculous mycobacterial pulmonary disease and longitudinal changes on ct before diagnosis. *Heliyon*. 2024;10(9):e30060. doi:10.1016/j.heliyon.2024.e30060
12. Morimoto K, Gallagher JR, Wagner D, et al. Real-world patients' diagnosis-to-treatment journey with nontuberculous mycobacterial pulmonary disease: a cross-sectional survey. *Infect Dis Ther*. 2024;13(8):1907–1920. doi:10.1007/s40121-024-01015-z
13. Morimoto K, Daley CL. Comprehensive management algorithm for mycobacterium avium complex pulmonary disease in the real-world setting. *Ann Am Thorac Soc*. 2025;22(5):651–659. doi:10.1513/AnnalsATS.202408-904FR
14. Cai C, Zeng W, Wang H, et al. Neutrophil-to-lymphocyte ratio (nlr), platelet-to-lymphocyte ratio (plr) and monocyte-to-lymphocyte ratio (mlr) as biomarkers in diagnosis evaluation of acute exacerbation of chronic obstructive pulmonary disease: a retrospective, observational study. *Int J Chron Obstruct Pulmon Dis*. 2024;19:933–943. doi:10.2147/COPD.S452444
15. Liu H, Li Y, Yi J, et al. Neutrophil-lymphocyte ratio as a potential marker for differential diagnosis between spinal tuberculosis and pyogenic spinal infection. *J Orthop Surg Res*. 2022;17(1):357. doi:10.1186/s13018-022-03250-x
16. Li D, Gu H, Chen L, et al. Neutrophil-to-lymphocyte ratio as a predictor of poor outcomes of mycoplasma pneumoniae pneumonia. *Front Immunol*. 2023;14:1302702. doi:10.3389/fimmu.2023.1302702
17. Ng WW, Lam S, Yan W, et al. Nlr, mlr, plr and rdw to predict outcome and differentiate between viral and bacterial pneumonia in the intensive care unit. *Sci Rep*. 2022;12(1):15974. doi:10.1038/s41598-022-20385-3
18. Stojkov D, Gigon L, Peng S, et al. Physiological and pathophysiological roles of metabolic pathways for NET formation and other neutrophil functions. *Front Immunol*. 2022;13:826515. doi:10.3389/fimmu.2022.826515
19. Nappi F. To gain insights into the pathophysiological mechanisms of the thrombo-inflammatory process in the atherosclerotic plaque. *Int J Mol Sci*. 2023;25(1):47. doi:10.3390/ijms25010047
20. Zumwinkel M, Chirambo A, Zähnle M, et al. Polycytotoxic T cells mediate antimicrobial activity against intracellular mycobacterium tuberculosis. *Infect Immun*. 2025;93(1):e0029724. doi:10.1128/iai.00297-24
21. Chang E, Cavallo K, Behar SM. CD4 T cell dysfunction is associated with bacterial recrudescence during chronic tuberculosis. *Nat Commun*. 2025;16(1):2636. doi:10.1038/s41467-025-57819-1
22. Gopalaswamy R, Shanmugam S, Mondal R, et al. Of tuberculosis and non-tuberculous mycobacterial infections - a comparative analysis of epidemiology, diagnosis and treatment. *J Biomed Sci*. 2020;27(1):74. doi:10.1186/s12929-020-00667-6
23. Opperman C, Singh S, Ghebrekristos Y, et al. Pulmonary non-tuberculous mycobacteria and mycobacterium tuberculosis complex co-infection: a pragmatic approach to its diagnosis and management in South Africa. *S Afr Med J*. 2024:114:e2313. doi:10.7196/SAMJ.2024.v114i9.2313
24. Kumar K, Loebinger MR. Concomitant or sequential pulmonary infection with non-tuberculous mycobacteria and aspergillus. *Int J Tuberc Lung Dis*. 2023;27(11):797–802. doi:10.5588/ijtld.23.0215
25. Fayos M, Silva JT, Lopez-Medrano F, et al. Non-tuberculous mycobacteria and aspergillus lung co-infection: systematic review. *J Clin Med*. 2022;12(1):11. doi:10.3390/jcm11195619
26. He X, Hou H, Jiang Y, et al. Association between indices of peripheral blood inflammation and cavitary pulmonary tuberculosis. *Int J Gen Med*. 2024;17:5133–5142. doi:10.2147/IJGM.S483185
27. Tu H, Lai T, Chen Y, et al. Hematological parameters as potential markers for distinguishing pulmonary tuberculosis from genitourinary tuberculosis. *Pathogens*. 2023;13(1):12. doi:10.3390/pathogens12010084
28. Yu Q, Luo H, Hu S, et al. The survival analysis of rifampicin/multidrug-resistant tuberculosis patients based on the levels of inflammatory biomarkers: a retrospective cohort study. *Front Cell Infect Microbiol*. 2023;13:1118424. doi:10.3389/fcimb.2023.1118424
29. Zhang X, Fu H, Li J, et al. Development and validation of a predictive model using inflammatory biomarkers for active tuberculosis risk in diabetic patients. *J Inflamm Res*. 2025;18:4725–4739. doi:10.2147/JIR.S512075
30. Kim KJ, Chang Y, Yun SG, et al. Evaluation of a commercial multiplex real-time pcr with melting curve analysis for the detection of mycobacterium tuberculosis complex and five nontuberculous mycobacterial species. *Microorganisms*. 2024;13(1):13. doi:10.3390/microorganisms13010026
31. Lim J, Kim C, Bae MH. Evaluation of the performance of two real-time PCR assays for detecting mycobacterium species. *J Clin Lab Anal*. 2019;33 (1):e22645. doi:10.1002/jcla.22645